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Thermoluminescence Study of Gd_2O_3: Er^{3+},Yb^{3+}

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ABSTRACT

The present paper reports that the thermoluminescence studies of Gd_2O_3: $Er^{3+,}$ Yb^{3+}. Gd_2O_3: Er^{3+}, Yb^{3+} prepared by combustion synthesis method Thermoluminescence glow curves of the prepared samples were recorded for UV radiation and their TL parameters was calculated. We also calculate the shape factor, order of kinetics, activation energy & frequency factor for the present sample.

Keywords: Gd_2O_3: Er^{3+}, Yb^{3+}, Combustion synthesis, thermoluminescence.

1. INTRODUCTION

Rare-earth doped oxide particles have been widely studied for application to displays such as high definition (HD), projection televisions (PTVs), and flat panel displays (FPDs). Phosphor materials must have a narrow size distribution, non-agglomeration properties, and spherical morphology for good luminescent characteristics. The mean size of the particles is very important for high resolution and high efficiency[1].

The current interest in this field is focused on synthesizing Phosphors materials using improved techniques and looking for their new applications. Out of various phosphors, Er^{3+}/Yb^{3+} doped Gd_2O_3 upconversion (UC) Phosphors has been found to be highly efficient and has been successfully used in different applications[2–7]. The high quantum yield is due to low phonon energy of the Gd_2O_3 based host materials. Gd_2O_3 is excellent host matrix of upconversion luminescence because it has better chemical durability, thermal stability, and lower phonon energy[8,9].

Thermoluminescence (TL) is the emission of light observed during the heating of insulating or semiconductor materials, provided that they have been previously exposed to ionising radiation (McKeever 1985; Martini M. Meinnardi, 1997; Chen and McKeever, 1997)[10-12].

2.1. SAMPLE PREPARATION

In this study Gadolinium Nitrate (99.99% Sigma Aldrich) Erbium nitrate (99.99% Sigma Aldrich) and ytterbium nitrate(99.99% Sigma Aldrich), urea were used as starting raw material. To prepare Gd_2O_3: Er^{3+}, Yb^{3+}, These Gd_2O_3 $(NO_3)_3$ $Er(NO_3)_3$ and $Yb(NO_3)_3$ were mixed according to the stoichiometry equation in a beaker and then a suitable amount of urea was added to prepare the precursor solution and kept stirring for 30 min. Finally this sample was transferred to crucible and fired in a furnace then water was evaporated quickly and soon a vigorous redox reaction occurred, the whole process went on for a few seconds at 600^0C. Finally Gd_2O_3: Er^{3+},Yb^{3+}nanoparticles with different concentration were obtained.

2.2. STRUCTURAL CHARACTERIZATION

The morphologies and sizes of the rare earth doped Gd_2O_3 were determined by X-ray diffraction studies with Cu Kα radiation (λ=1.5418 A^o). XRD data were collected over the range 20^o-80^o at room temperature. The X-ray diffraction patterns have been obtained data from X-ray Powder diffractometer. The particle size was determined using the sherrer's formula.

3. RESULTS AND DISCUSSION

3.1. Structural characterization

The XRD patterns of Gd_2O_3: Er^{3+}, Yb^{3+}, synthesis at 600 C° temperature by combustion synthesis shown in Fig. 1.

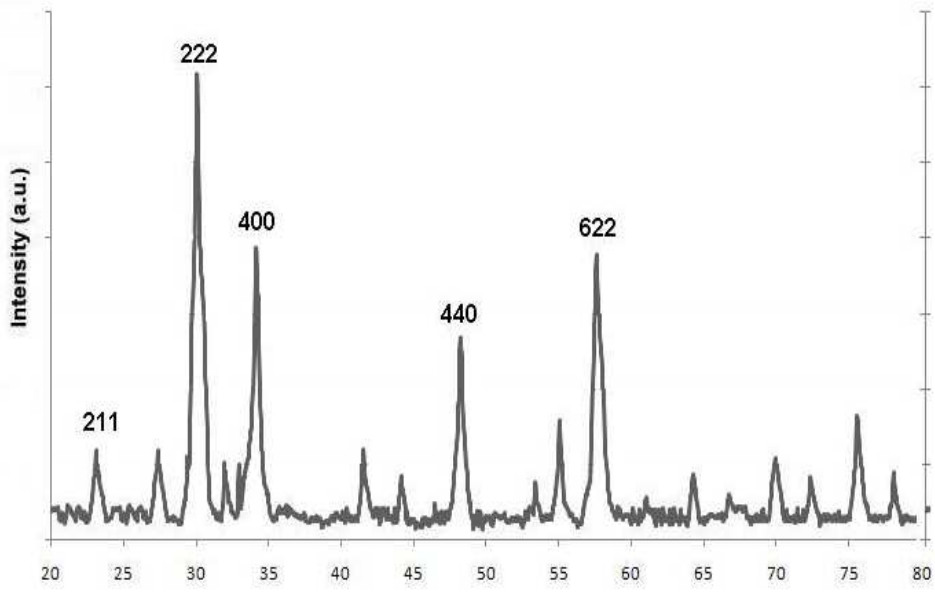

Fig. 1 XRD pattern of Gd_2O_3: Er^{3+}, Yb^{3+}

Four different peaks are obtained at 2 θ values of 30.04^0 , 34.12^o, 48.20^o and 57.56^o. and the peaks correspond to diffraction at (211),(222) , (400) and (622) planes, respectively .

All diffraction patterns are in good agreement with JCPDS NO.43-1014 reference, The size of the particles has been computed from the width of first peak using Debye Scherrer formula[13]:

$$D = 0.89\lambda/\beta\cos\theta$$

Where λ is the wavelength of the X-ray, θ is the diffraction pattern angle and β is the corrected full width at half maximum (FWHM) of the XRD peaks (corresponding to 2θ).

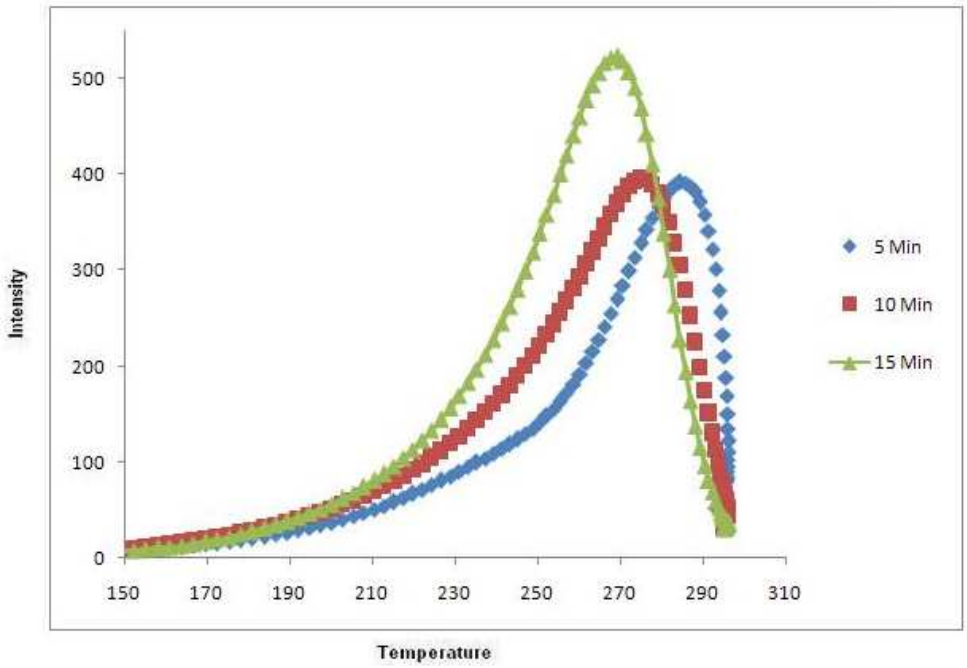

Fig. 2 TL glow curve of Gd_2O_3: Er^{3+}, Yb^{3+} with different UV exposure time

Figure 2 shows the TL glow curve of Er^{3+}, Yb^{3+} doped Gd_2O_3 nanophosphor. From this figure the kinetic parameters is calculated by peak shape methods and evaluate the parameters such as activation energy, frequency factor and order of kinetics of the prepared nanophosphor. The glow curve shifted lower temperature side as a function of UV exposure and the corresponding value of activation energy and frequency factor is shown in Table1. The glow curve show first order kinetics because value of μ its called shape factor is >0.42 so the TL glow curve shows first order kinetics.

Table 1 Kinetic Parameters of Gd_2O_3: Er^{3+}, Yb^{3+}

UV exposure time	T_1 (K)	T_m(K)	T_2(K)	$\tau = (T_\mu - T_1)$	$\delta = (T_2 - T_\mu)$	$\omega = (T_2 - T_1)$	$\mu = \delta / \omega$	Activation energy E	Frequency factor
5 min	528.21	557.53	568.3	29.32	10.77	40.09	0.26	1.33	1.52×10^{13}
10 min	519.99	547.97	562.36	27.98	14.39	42.37	0.33	1.35	4.69×10^{13}
15 min	516.28	542.21	556.22	25.93	14.01	39.94	0.35	1.44	3.92×10^{14}

CONCLUSION

The dependence of shape factor of thermoluminescence (TL) peak exhibiting thermal quenching on the energy (W), characterizing the non – radiative process has been thoroughly studied. The shape factor of the first order kinetics is less than 0.4 whereas for a second order kinetics it may be vary from 0.52 to even 0.426 depending on the degree of thermal quenching. This finding gives a caution to the TL workers before reporting general order kinetics without the prior checking of the presence or absence of thermal quenching. Also the value shows the trapping parameters and low fading because the curves shift to the lower temperature side. The value of activation energy belongs to 1.33eV to 1.44 eV and frequency factor $1.52\times10^{13}$to 3.92×10^{14}.

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